CLAIMS

We claim:

1.   A method of washing an upflow filter between service runs, said upflow filter including a filter bed having a non-buoyant particulate media filter layer through which influent to be filtered is directed in an upward direction during each service run for causing floc in said influent to be retained in said layer, said method of washing including the steps of:

(a)   directing a combination of air and liquid in an upflow direction through the filter layer with the velocity of the liquid being less than the minimum fluidization velocity of the filter layer for disrupting only some floc retained in said layer during a previous service run, while leaving some floc attached to said particulate media in said filter layer; and thereafter

(b)   directing only liquid in an upflow direction through the filter layer at a velocity less than the minimum fluidization velocity of the filter layer for removing disrupted floc from the filter while leaving in said layer floc attached to said particulate media of said filter layer.

2.   The method of claim 1 wherein the liquid directed in an upflow direction in steps (a) and (b) is the influent liquid directed through the filter layer during service runs.

3.   The method of claim 2 wherein the liquid directed through the filter layer in steps (a) and (b) (c) of claim 1 is at substantially the same velocity as the velocity of the influent during the service runs.

4.   The method of claim 1 wherein the step of directing a combination of air and liquid in an upflow direction through the filter layer is terminated while the liquid is turbid with floc, and with the headloss through the filter layer being at least fifteen percent (15%) greater than the headloss through said layer when said layer is free of floc.

~~5.~~ 4.   The method of claim 1 wherein the rate of air flow in step (a) is approximately Q_a, wherein, when the Reynolds number based on $d_{60\%}$ and the minimum fluidization velocity is 10 or less:

$$Qa = [93.11 - 5.83 \times 10^4 \, V \, d_{60\%}^{-1.82} \, (sg-1)^{-0.94} \, p^{-1.88} \, \mu^{0.88}]^{\frac{1}{2}};$$

and when the Reynolds number based on $d_{60\%}$ and V_{mf} is greater than 10, the air scrub rate is approximately

$$Qa = [93.11 - 2116 \, V \, d_{60\%}^{-1.053} \, (sg-1)^{-0.684} \, p^{-1.097} \, \mu^{0.369}]^{\frac{1}{2}}$$

with "V" being the velocity of the liquid in gallons per minute per square foot; "$d_{60\%}$" being the 60% size of the media particles in millimeters (equal to the product of the uniformity coefficient of the particles and the effective size of the particles); "sg" being the specific gravity of the particles, "p" being the

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82 density of the liquid in lbs/cu.ft. and "μ" being the viscosity of the liquid in centipoise.

5. 6. The method of claim 1 wherein the velocity of the liquid in steps (a) and (b) is less than one-half the minimum fluidization velocity of the filter layer.

7. The method of claim 6 wherein the velocity of the liquid in steps (a) and (b) of claim 1 is in the range of approximately 5-20 gallons per minute/sq.ft., and the rate of air flow in step (a) of claim 1 is in the range of approximately 1-9 standard cubic feet per minute/sq.ft.

8. The method of claim 2 wherein the velocity of the liquid in steps (a) and (b) of claim 1 is in the range of approximately 5-20 gallons per minute/sq.ft., and the rate of air flow in step (a) of claim 1 is in the range of approximately 1-9 standard cubic feet per minute/sq.ft.

9. The method of claim 3 wherein the velocity of the liquid in steps (a) and (b) of claim 1 is in the range of approximately 5-20 gallons per minute/sq.ft., and the rate of air flow in step (a) of claim 1 is in the range of approximately 1-9 standard cubic feet per minute/sq.ft.

10. The method of claim 2 wherein the step of directing a combination of air and liquid in an upflow direction through the filter layer is terminated while the liquid is turbid with floc, and with the headloss through the filter layer being at least fifteen percent (15%) greater than the headloss through said layer when said layer is free of floc.

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11. The method of claim 3 wherein the step of directing a combination of air and liquid in an upflow direction through the filter layer is terminated while the liquid is turbid with floc, and with the headloss through the filter layer being at least fifteen percent (15%) greater than the headloss through said layer when said layer is free of floc.

6, 12. The method of claim 1 wherein step (a) is carried out for a period of less than five (5) minutes, ~~after which the liquid is turbid~~.

7, 13. The method of claim 12 wherein step (c) (b) is carried out for a period of less than five (5) minutes, ~~after which the liquid is turbid~~.

14. The method of claim 12 wherein the velocity of the liquid in steps (a) and (b) of claim 1 is in the range of approximately 5-20 gallons per minute/sq.ft., and the rate of air flow in step (a) of claim 1 is in the range of approximately 1-9 standard cubic feet per minute/sq.ft.

15. The method of claim 13 wherein the velocity of the liquid in steps (a) and (b) of claim 1 is in the range of approximately 5-20 gallons per minute/sq.ft., and the rate of air flow in step (a) of claim 1 is in the range of approximately 1-9 standard cubic feet per minute/sq.ft.

8, 16. The method of claim 1 including the step of forming said filter bed with a static flocculation layer of particulate, non-buoyant material that is coarser than said filter layer and is disposed upstream of said filter layer, in

the direction of liquid flow through the filter bed, said particulate, non-buoyant material of said flocculation layer having particles of an effective size and uniformity coefficient for distributing the upward flow of influent during service runs and providing a velocity gradient for mixing said influent to promote flocculation without retaining substantial portions of floc in said layer.

9, 17. The method of claim 16 wherein the depth of said flocculation layer is less than the depth of said filter layer.

10, 18. The method of claim 1 wherein the particulate material of the filter layer has an effective size greater than one (1) millimeter to provide a coarse layer, said influent directed through the filter layer in an upflow direction having a low solids content with turbidity less than 100 NTU.

11, 19. The method of claim 18 wherein the particulate material of the filter layer has an effective size greater than one (1) millimeter to provide a coarse layer, said influent directed through the filter layer in an upflow direction having a low solids content with turbidity less than 100 NTU.

12, 20. The method of claim 19 wherein the effective size of the particles in the flocculation layer is in excess of 2 millimeters.

13, 21. The method of claim 16 including the step of providing a transitional layer of particulate material between the flocculation layer and the filter layer, said flocculation

layer through which influent first passes being coarser than the transitional layer.

14, 22. The method of claim 13 wherein the effective size of the particles in said flocculation layer is no greater than 6.5 millimeters, and the effective size of the particles in the transitional layer is approximately 2.5-3.5 millimeters.

15, 23. The method of claim 1, including the step of forming the non-buoyant filter layer of particulate media having a specific gravity in excess of 2.

16, 24. The method of claim 8 wherein the flocculation layer and the filter layer have specific gravities greater than 2.

17, 25. The method of claim 8 including the step of providing a flocculation layer having particles with an effective size greater than 4 millimeters.

18, 26. The method of claim 18 wherein the flocculation layer has a particle size and porosity for providing a velocity gradient of between approximately 40 and 60 reciprocal seconds at a flow rate of influent therethrough in the range of 10 to 15 gallons per minute/sq.ft.

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